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Consultant Report on China Small-Scale Wood Gasification Project

IDRC File 3-P-86-0246/6

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SUMMARY

A visit was made to the RICPUFP in Nanjing and to the Bi Shui Forest Farm near Dialing to inspect the technical progress achieved during the first ten months of the IDRC wood gasification project.

Sub-project 1, District Heating in Northern China, is on schedule although various construction, shipping and installation delays plus an increased work scope have prevented the anticipated early implementation of the system. A complete new gasifier with improved materials, a redesigned grate and ash removal system, and upgraded instrumentation and controls was fabricated and installed as well as a new packaged boiler (natural gas design). A rotary valve chip feeder on the gasifier proved inoperable and the gasifier has not yet been fired. A chip storage/drier bin and screw auger feeder have been constructed and shipped to the site. No work has been carried out on fuel procurement; a stationary chipper was purchased but insufficient electrical capacity at the site has prevented its installation.

Sub-project 2, Laboratory Study on Gas Quality Improvement, has progressed very well and is several months ahead of schedule. A laboratory scale two-stage system (updraft gasifier - downdraft cracker) has been designed, constructed and installed. Instrumentation is being assembled and a near-term test firing is expected. A gas cooling and cleaning system is in place and a 5 kw genset is installed, ready for operation.

Little effort has been devoted to sub-project 3, Industrial Gasification Retrofits and Electricity Generation in Southern China, which is now behind schedule. The project team has requested that the scope of this sub-project be reduced and the funds allocated to a new sub-project to demonstrate the use of wood gas for household cooking. A proposal for this activity has been prepared.

WORK MANDATE

Specific objectives as defined by IDRC were:

1) To travel to China for review of the Wood Gasification (China) project being carried out by the Research Institute of Chemical Processing and Utilization of Forest Products, Chinese Academy of Forestry.

2) To review the work accomplished during the first year of the project, discuss problems with the project team, and assist with definition of the methodology and work program for the second year of the project.

3) To discuss requirements for training of a Chinese Scientist in Canada with respect to biomass energy research.

4) To prepare a project review report.

ITINERARY

APRIL 12-13	Travel, Ottawa to Beijing.
APRIL 14	Tour of Academy of Forestry Research Facilities Meeting with Academy Officials. Discussion of Finger-Jointing Project. General Review of Gasification Project with Project Leader and Engineers.
APRIL 17	By plane to Harbin. Meeting with Officials from General Bureau of Forest Industry, Heilongjiang Province.
APRIL 18	By train to Dialing. Review of Project Staff changes. Initial discussion of proposed wood-gas cooking demonstration.
APRIL 19	On-site inspection of gasifier-boiler at Bi Shui Forest Farm. Examination of dryer bin and screw feed auger in Dialing. Visit to stationary chipper and chip screen at pulp mill in Dialing.

APRIL 20	By train to Harbin. Detailed review of chip fuel handling and feeder design options.
APRIL 21	Tour of coal-gas distribution centre and examination of household coal-gas stove operation. Leave by train for Nanjing.
APRIL 22	By train to Nanjing. Preparation of budget and work schedule for proposed wood-gas cooking demonstration.
APRIL 23	Inspection of laboratory gasifier-cracker. Detailed review of sub-project 2.
APRIL 24	Writeup of proposal for sub-project 4, wood-gas cooking demonstration. Leave by train for Beijing.
APRIL 25	By train to Beijing.
APRIL 26	Travel, Beijing to Ottawa.

PROJECT REVIEW

SUB-PROJECT 1: District Heating in Northern China

General Status

The wood-chip gasifier district heating sub-project is roughly on schedule although the targeted rate of progress has not been realized (It was anticipated that this project would run well ahead of schedule). Several scheduled work segments have not been addressed but considerably greater effort has been devoted to gasifier improvements. It was decided that the required gasifier modifications could best be achieved through design and construction of a completely new gasifier. A new package boiler was also aquired.

During the 1986-87 heating season the original gasifier was operated for two days of intensive experimentation plus several short duration tests. The high manpower requirement for manual fuel elevation and feeding, and difficulties with ash removal precluded operation on a regular basis. The building heat load was supplied through combustion of coal in the existing boiler.

Design of the new gasifier was completed by July 1987 with construction completed by the end of October. The gasifier was shipped from Nanjing to Dialing and installation finished by mid-February 1988. A simple feed chute and rice hull rotary valve (Appendix I, Figure 6) were attached and chip feed tests conducted. These tests were not successful and the gasifier has not yet been run.

A screw auger feeder and dryer bin design were completed by early March and constructed in 15 days. These units were shipped to Dialing and had just arrived at the train station.

Technical Progress

Gasifier

The new gasifier (Appendix I, Figure 1) incorporates a cone-shaped, ribbed grate cast from heat resistant steel (Cr25 Ni10). This material is able to withstand continuous exposure to 1100-1150 C with short-term exposure to 1300 C. The grate is rotated by an electric motor and gear reduction unit (Appendix I, Figure 4) that is manually activated when required. The grate rotation will break up any ash agglomeration. A water-seal trough (which rotates with the grate) quenches and collects the ash while a stationary ash plough will scoop up and remove the ash.

The heat resistant steel section of the inner gasifier shell was increased in height from 40 cm to 80 cm because thermocouple temperatures measured in the old gasifier had indicated levels of 1100 C, too high for extended operation with normal steel.

Improved instrumentation has been incorporated in the new system. Additional thermocouples have been added, a unified control panel has been installed (Appendix I, Figure 2) and the rupture discs (for explosion protection) have been replaced by water seals.

Boiler and Heat Distribution System

After discussions with the Ministry of Forestry funds were aquired for the purchase of a new natural gas hot water boiler rated at 1.2 GJ/h (Appendix I, Figure 3). This unit has been fitted with a pre-mix burner for combustion of wood-gas (Appendix I, Figure 5) and installed in parallel with the original coal-fired boiler. It is still planned to carry out the modifications to the coal boiler (to optimize wood -gas firing) since there are a large number of these units that could be retrofitted.

The heat distribution system consists of about 835 m of double line (feed and return) in two main loops. One loop of 445 m serves 9 units of row housing with a total area of about 1620 m2. They are located about 190 m from the boiler house. A second loop of about 390 m provides heat to shops and offices, a total of 8 buildings of about 1750 m2. The distribution lines are steel pipes (52 mm diameter for main lines and 32 or 25 mm diameter for feeders) with a foam insulation and fiber wrapping and are mostly underground.

Water is circulated by a 4 kW electric pump (with a second standby pump in parallel) at a velocity of about 1.5 m/s and capacity of about 10 t/h. The outlet water temperature at the boiler is 70-80 C with the return temperature about 10 C lower. It is estimated that total distribution losses are about 10%. Heat is delivered on a cyclic basis with water circulation governed by heat demand (about every 2 hours) and boiler operation cycled on the basis of water temperature. The normal heating season is September 15 to April 15.

Fuel Preparation

Additional chip production trials have not been attempted. Previous work showed that although the mobile chipper was rated at 8 m3/h it was actually able to produce only about 2 m3/h. Knives required frequent changing since efficiency dropped sharply as the knives were dulled. The small feed chute meant that any crooked material was difficult to feed.

The smallest available electrically powered stationary chipper was purchased (Appendix I, Figure 10). Unfortunately it requires 55 kW and the electrical transformer system at the forest farm site is only good for 50 kW, consequently hookup was not allowed and the chipper has not been run. If the project is successful the forest farm will upgrade their electrical system to permit chipper installation. Chips for gasifier testing will be supplied by the mobile unit or obtained from a pulp chip system in Dialing (Appendix I, Figure 11, 12).

Comments

Chip Dryer Bin and Feed System

Unfortunately the apparent weak link in the gasifier system is the chip handling and feeding component. This is consistant with general practice wherin the vast majority of bioenergy system failures have been directly related to fuel handling. Standard components borrowed from other areas of materials handling which are designed for free-flowing, granular feedstocks will not function on chips (particularly fuel chips which contain bark strings and flexible twigs). The accepted practice of combining metering and feeding, which works very well for rice-hulls, grain or coal, is not suitable for fibrous biofuels. Experience has shown that metering (or flow rate control), transport, and feeding (injecting into a reactor while limiting gas exit) must be separated into distinct functions accomplished by different pieces of equipment.

Feeding of biofuels into reactors can be achieved by: lock hoppers, rotary valves, rams, or plug forming screw augers.

Screw Augers. These have been used on large reactors. They achieve sealing by forming a dense plug of material which is extruded into the reactor. Power requirements are very high, erosion of screw components is rapid and performance on chips is much less satisfactory than on fine materials such as sawdust. A normal enclosed screw auger (Appendix I, Figure 9) will not prevent backflow of tarry gases from the reactor and is prone to jamming when chips wedge between the flights and the casing. Screw augers (especially open trough designs) function well as transport devices if metering is done prior to the auger. Best results are obtained by operating the screw at relatively high speed with a volumetric loading of about 20%.

Rotary Valves. These can operate as chip feeders (provided there are no large twigs or splinters) when the flow is metered prior to the valve so that the valve pockets are only partially filled and the vanes are not required to shear through a standing column of chips. A gas purge is required to prevent escape of reactor gases during operation.

Rams. Rams are used very effectively on large systems such as incinerators for municipal or industrial wastes. They require high power levels, are relatively slow acting, and generally do not seal effectively against pressure.

Lock Hoppers. These have been the most successful feeders for coarse biomass fuels. They are simple, effective and fast acting. Metering must be carried out prior to the lock hopper so that the knife valves are not required to shear through a chip column. A gas purge is required to completely eliminate reactor gas escape during cycling.

The dryer bin design (Appendix I, Figures 7,8) does not appear to be based on principles of mass flow and the potential for satisfactory performance on fuel chips seems remote. The flue gas inlet slots, while probably effective in gas distribution, will restrict flow along the bin walls and promote bridging. Provision has been made for a mechanical agitator to improve flow; however, the basic design of the bin suggests that fuel flow will be a continuing major problem.

Fuel Chip Economics

There seems to be some question as to the potential economic viability of converting from coal and firewood to fuel chips at the forest farm. Coal cost in 87-88 was given as 60 CY/t fob Dialing with about 5 CY/t the cost of trucking to Bi Shui. Fuel energy cost would therefore be 2.2-3.1 CY/GJ.

The value of solid firewood was difficult for forest farm officials to estimate accurately but was given as about 5.34 CY per m3 loose pile of about 300 kg at 50% MC. With about 2 CY/m3 added for labour the equivalent cost would be about 48 CY/dry t or about 2.4 CY/GJ.

Fuel chips produced by the mobile chipper (with a crew of 10) were estimated to cost about 18 CY/m3 bulk volume. Assuming 250-300 dry kg/m3 would give a chip cost of 60-72 CY/t or 3.0-3.6 CY/GJ. Limited data from collection and transport of branches for producing pulp chips suggest a cost of about 26 CY/m3 bulk volume or 4.4-5.2 CY/GJ.

Comments from Bi Shui officials in 1986 suggested that fuel chips were roughly half the cost of coal. Apparently the rapidly changing economic conditions and high inflation rates have significantly increased the cost of local labour as well as equipment and supplies.

Project Problems

A number of problem areas have been noted that have delayed or increased costs for the project at Bi Shui.

* Slow gasifier construction, particularly with respect to components fabricated from heat resistant alloys.

* Prolonged transportation times to ship components from Nanjing to Dialing.

* Local shortages (in Dialing) of material required for installation and maintenance.

* Some lack of local support. During the winter harvest season local labour is unavailable and there is some reluctance to provide support since near term benefits are not readily apparent.

* Difficulty to work outside in winter and problems with transport for the project staff from living quarters in Dialing.

Recommendations

1. Chip dryer bin

The chip bin should be set up on a temporary yard framework, the opening fitted with a simple swing-away cover and chip flow tests carried out immediately. Tests should be initiated with screened pulp chips and should cover various depths of chips in the bin and both live and consolidated (up to several days) storage.

If reasonably reliable, consistant flow from the bin cannot be achieved the bin design will require modification either to a live-bottom or mass-flow configuration.

2. Chip Feeder/Metering

Consideration should be given to design of an appropriate feed/metering system which seperates the three functions. An open metering system at the chip bin (variable speed live bottom or mechanical flow control by rotating table, belt or counter-rotating gates) could be combined with screw auger transfer to a lock hopper mounted on top of the gasifier.

3. Project Scheduling

Emphasis should be placed on achieving gasifier operation this summer in order to have the system available for full-scale, monitored performance during the next heating season. Another years delay could seriously erode local support and would cause a bottleneck during the final year when considerable project team effort must be devoted to sub-projects that are not yet underway.

Suggestion

Due to the changing economic conditions in China and to the new importance attached to economic viability it may be advisable to begin work on establishing the true comparative costs of fuel production (coal, firewood, chips, forest industry residues etc.). These financial considerations could then be integrated into a full evaluation of social benefits in order to present the complete case for retrofits in other locations.

SUB-PROJECT 2: Laboratory Study on Gas Quality Improvement

General Status

This sub-project has proceeded very well and is 4-5 months ahead of schedule. Design of the laboratory scale two-stage gasifier/cracker was completed by Autumn and construction and installation of the system components for the gasifier and gas cleaning system have been finished. At present the instrumentation and control system is being installed (Apppendix I, Figures 1,2,5,). A 5 kW engine-generator set was purchased and installed (Appendix I, Figure 7).

Technical Progress

Gasifier

Fuel chips are gravity fed from a hopper to a rotary valve through a clear flow-observation section (Appendix I, Figure 3). The valve feeds into the upper chamber of the updraft first stage. This low-temperature drying zone features a flow control throat, a condensate drain and provision for fuel height sensing and a spring loaded pressure relief valve.

The high-temperature lower section of the gasifier (with no fixed grate) is air-jacketed for final preheating of the air supply before it enters via tuyeres at the bottom of the pyrolysis/ gasification/combustion zone. Char is removed from the base of the reactor while off-gas is removed about mid-height of the fuel-storage/drying zone. Temperatures are recorded by thermocouples located at five levels within the reactor.

Cracker

Hot char from the updraft first-stage is transferred by a heat-resistant alloy screw auger to the top of the second-stage downdraft cracker/gasifier. The low-temperature off-gas from the first stage enters at the top of the upper section of the cracker. A flow-control throat separates the upper chamber from the lower gasification section which is supported by fixed alloy bar-grates (Appendix I, Figure 4). An air-jacket with baffles to promote circumferential flow is located between the gasifier inner shell and the outer gas flow shell. The final producer gas flow exits through the grate, turns in the ash dropout chamber and flows up an outer annulus to an upper exit and air-jacketed cyclone.

The second stage cracker/gasifier is fitted with thermocouples at five levels, a pressure relief valve and access ports for ash cleanout and char removal if required.

Gas Cleaning System

From the hot cyclone, gas is routed to the bottom of a counterflow wet scrubber (Appendix I, Figure 5). Water is circulated to a top spray ring and flows down through a bed of metallic rings supported on a grate. Off-gas from the top of the scrubber passes to a fabric filter (Appendix I, Figure 6) for final cleaning.

Engine-Generator Set

The 5 kW engine is a single cylinder diesel unit that has been converted to spark ignition and modified specifically for operation on biogas by the Engine Research Institute of Shanghai (Appendix I, Figure 7).

Comments

Chip Fuel Feed System

The chip hopper and rotary valve provided for fuel feed may be a problem area with possibility of fuel bridging at the hopper exit, jamming of the rotary valve and leakage of off-gases through the valve. Performance can be aided by using small screened chips and close operator attention. A hopper vibrator and an air-purge on the valve may be required.

Char Transfer System

The transfer of very high temperature char from the base of the first stage gasifier to the second stage cracker is probably the most critical aspect of the system. If too much air from the combustion zone in the first stage leaks through the char auger into the second stage a positive seal may be required. This can be determined only after operation and pressure balance optimization.

Char Level Control

At present there is no means (other than temperature sensing) to measure the char level in the cracker unit. Since char transfer is critical, a positive method of auger control based on char level sensing may be required.

Cracker Temperature Control

Provision may be required for injection of air into the cracker (to increase temperature), or injection of steam/water (to decrease temperature).

Recommendations

While there are several aspects of this gasifier-cracker that may present problems, only through operation of the unit can they be revealed. Startup should be achieved as soon as possible in order to provide an early indication of general performance since the viability of proposed sub-project 4 depends on success in producing a clean gas.

SUB-PROJECT 3: Industrial Gasification Retrofits and Electricity Generation in Southern China

General Status

With virtually no effort yet devoted to this sub-project it is behind schedule relative to the original timetable. The greater effort devoted to sub-project 1 (and the delays in achieving operation of the new gasifier) have not allowed design of the industrial version of the gasifier to proceed.

Im response to pressure for a cooking gas demonstration in northern China the project team has requested that the scope of sub-project 3 be reduced and the funds allocated to a new sub-project. A new proposal for this effort (sub-project 4) is provided in Appendix III.

The elements of sub-project 3 that would be deleted are objective (h), industrial electricity generation, and one of the two demonstrations in objective (g) (probably the retrofit of the brick kiln). The rationale for the proposed change includes the following points:

* Industrial sites which are now burning solid wood fuels (required for traditional forest products) can more easily be converted to direct combustion of particulate biomass fuels (or local coal) than can the household cooking applications in the northern forest regions.

* While desirable (from a demonstration point-of-view) the technical aspects of retrofitting two industrial sites with gasifiers are similar and a successful demonstration of a boiler retrofit should provide sufficient credibility for industrial uptake in other industries.

* If operation of the 5 kW laboratory engine-generator set is proven and the industrial gasifier can provide a gas of similar quality and cleanliness then the industrial generation of electricity should be a low-risk undertaking that can be supported by non-research funding.

Comments

Cooking with Producer Gas

While the piping of a high CO content gas into homes for open flame cooking would probably not be accepted in North America there is ample evidence of its widespread implementation in China based on coal gas systems. Safety precautions have been addressed both in the stove design and in the cooking setup in the home. Apparently the majority of the CO deaths (reported in Appendix III) are of workers involved in the generation and transmission of the gas with very few actual cases of poisoning in the homes (possibly no worse than CO related deaths in

North America from auto exhaust). There appears to be no technical reason that household cooking with wood gas cannot meet the accepted norms for Chinese coal gas systems.

Cutback on Industrial Retrofit Demonstrations

There is no question that several demos give greater credibility to a new technology than a single installation. However, there is considerable technical duplication and (provided a significant economic incentive exists) replications can often be achieved wholly within the industrial sector after a sufficient period of proven performance is achieved with an initial demonstration.

Suggestions

The new proposal (sub-project 4) can be evaluated on the basis of non-technical benefits including economic viability, social impact, governmental support, potential for widespread implementation and consumer acceptance. The prospects for technical success appear positive for either demonstration alternative (wood-gas cooking or brick kiln firing).

PROJECT TEAM CHANGES

Professor Jing Lei has retired from the institute and engineer Zhou Guoan has left the research group. Neither has yet been replaced. Tang Xioahua has been replaced by Wei Jiagou and Yian Linan by Zheng Wenhuai. It is anticipated that additional staff would be brought onto the project as the work requires.

TRAINING

The project team has suggested the following changes to the proposed training allocation.

* The overseas training be rescheduled to the third year of the project.

* The training period be reduced to one person (Engineer Wei Jiagou) for a period of about three months to study new pyrolysis/ gasification techniques.

* The extra funds (from reduced overseas training) be applied to an expanded study tour to examine basic applied gasification that would be applicable to China.

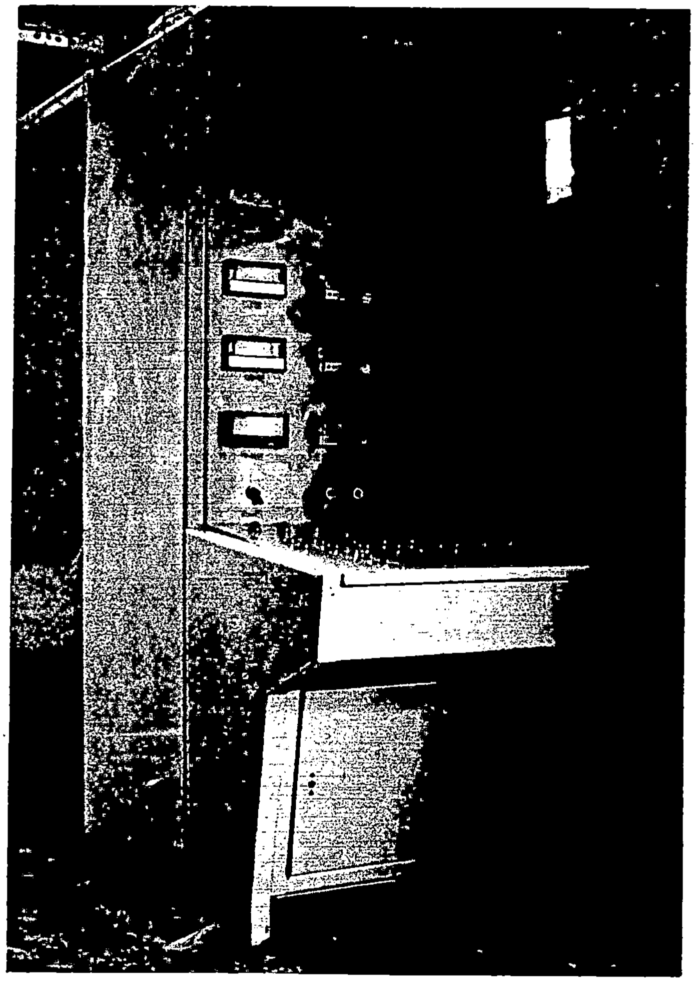
APPENDICES

APPENDIX I. PROJECT PHOTOGRAPHS

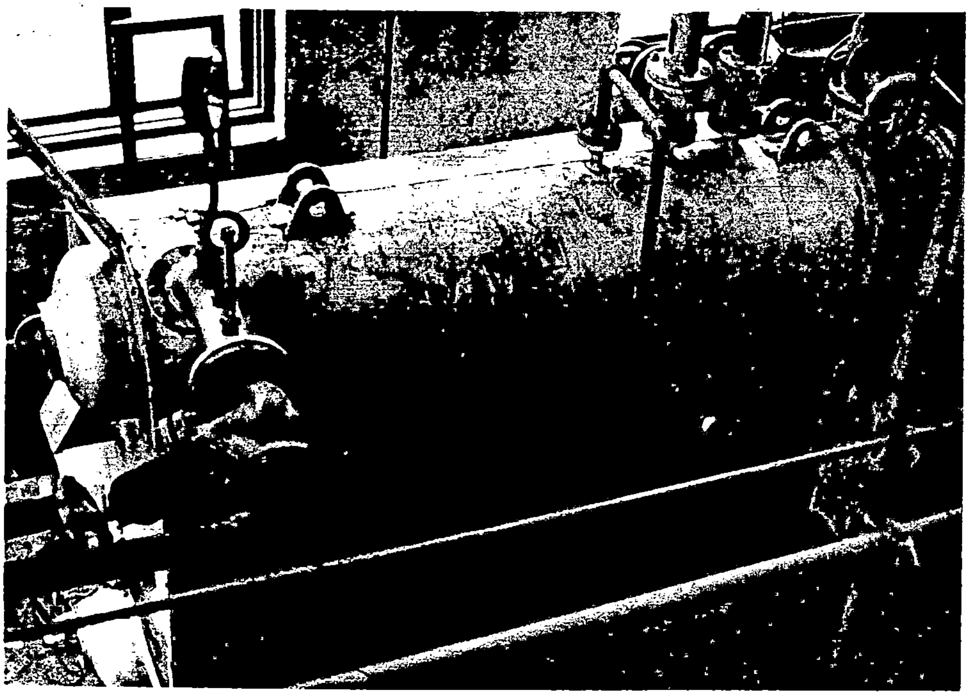
- SUB-PROJECT I
- SUB-PROJECT II
- SUB-PROJECT IV (PROPOSED)

APPENDIX 1. SUB-PROJECT I

1. New Gasifier



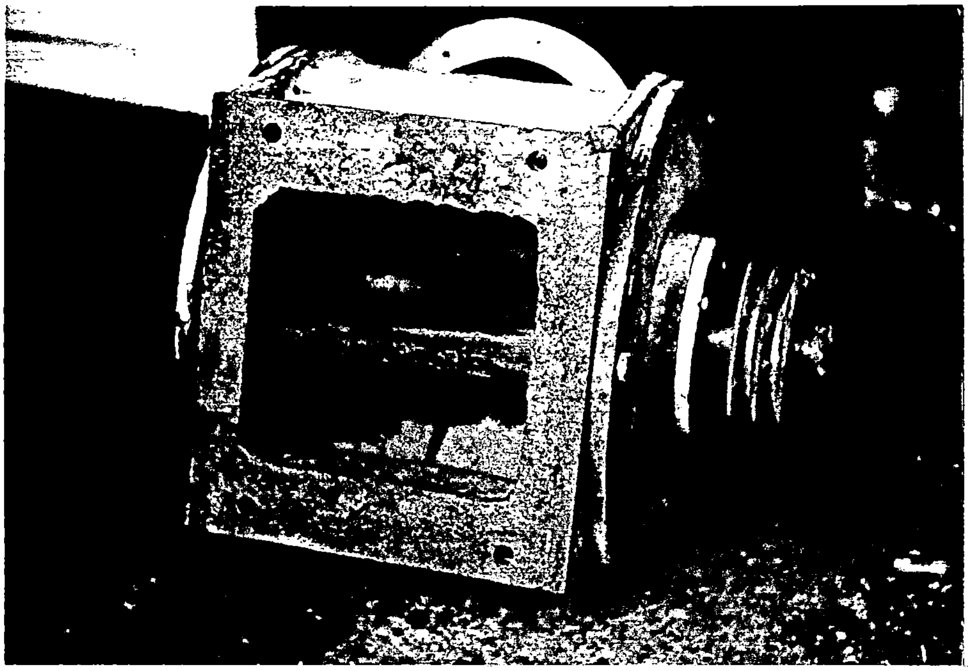
2. Gasifier Control Panel



3. New Hot Water Boiler

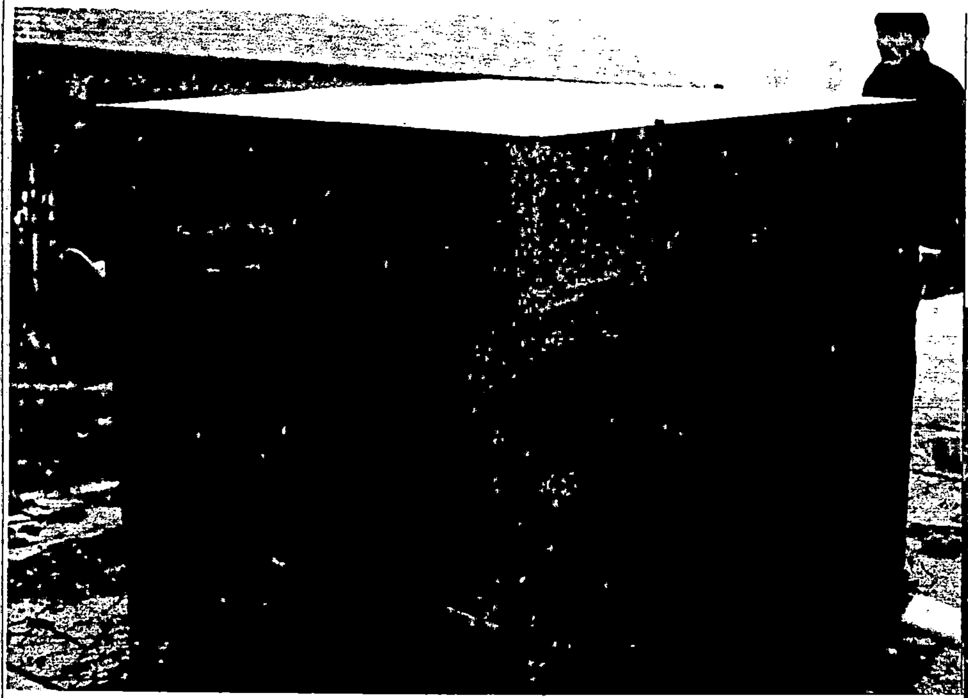
4. Drive for Rotating Grate

5. Pre-mix Burner



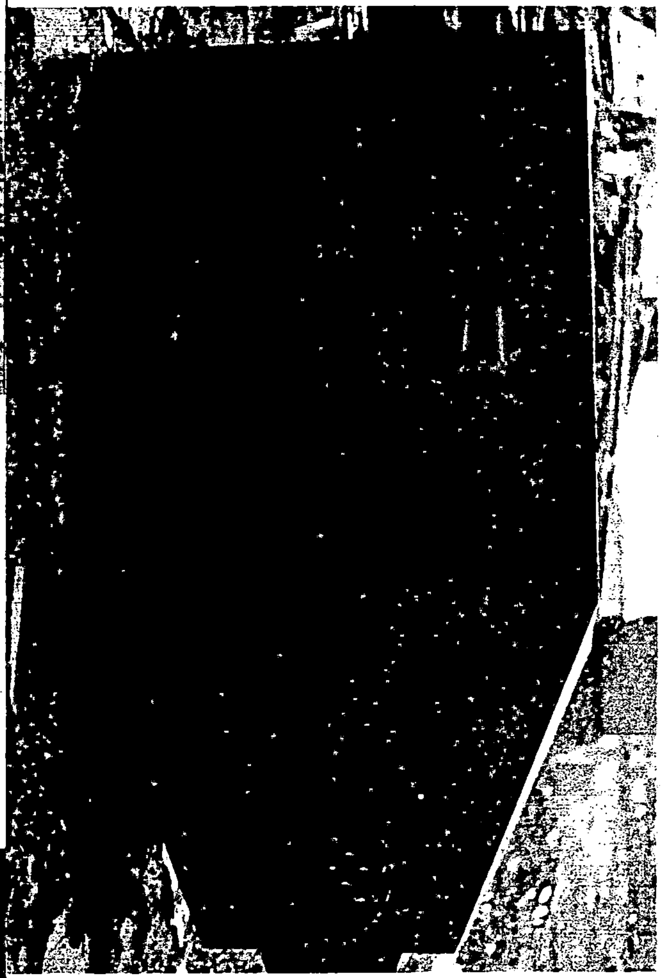
6. Rotary Valve Feeder

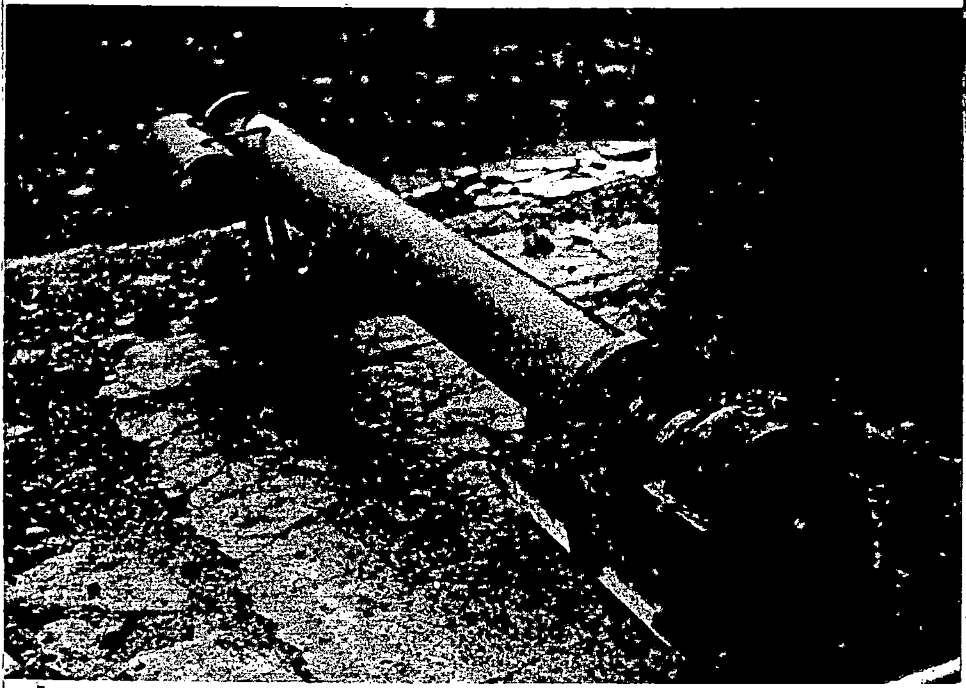
APPENDIX 1. SUB-PROJECT I



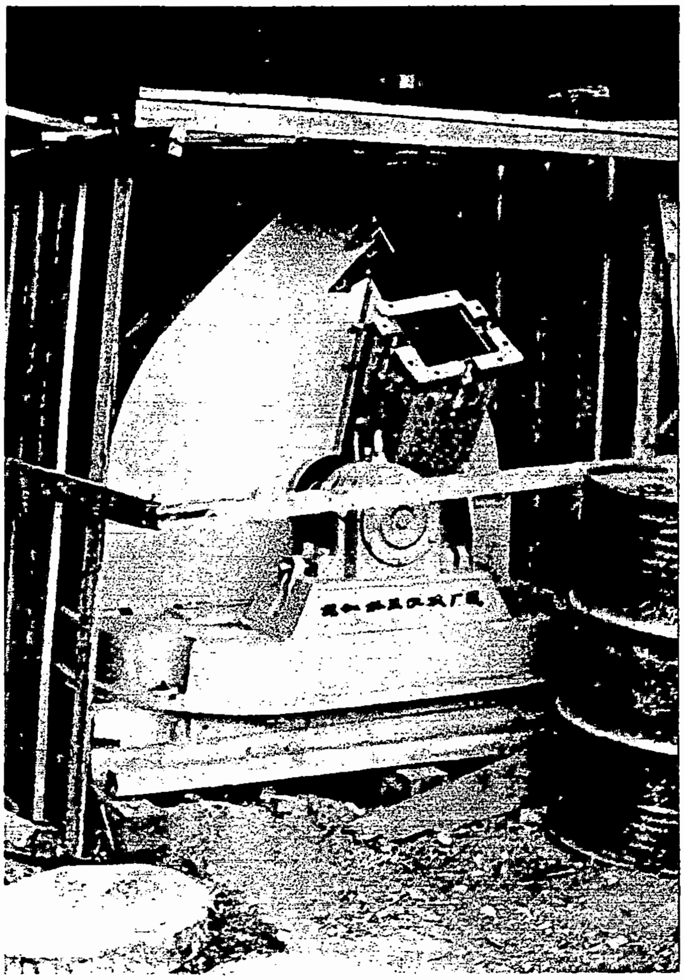
8. Chip Dryer Bin (side)

7. Chip Dryer Bin (top)

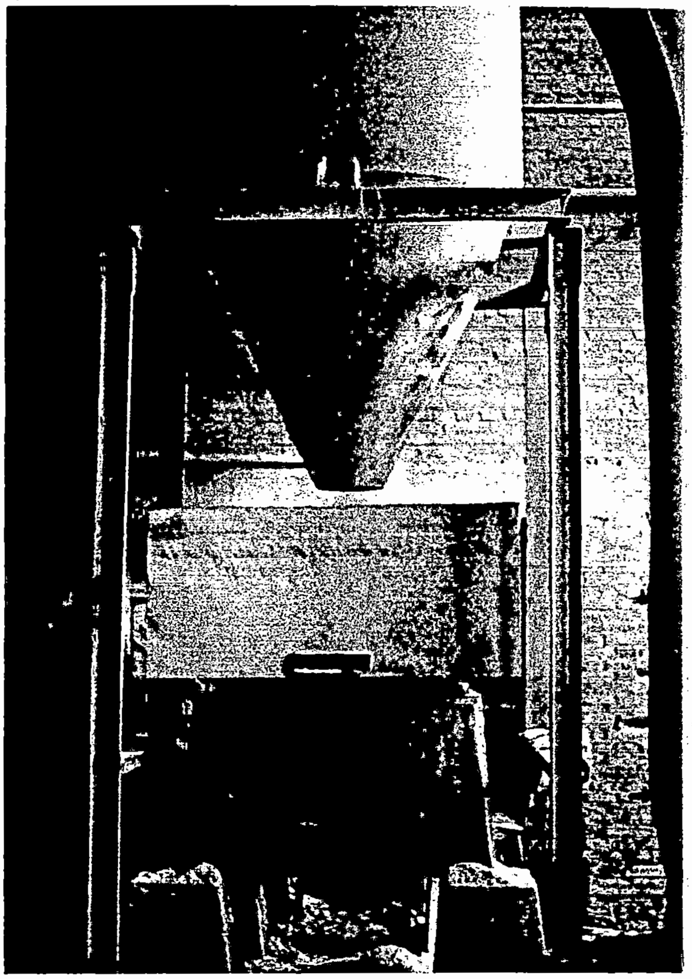




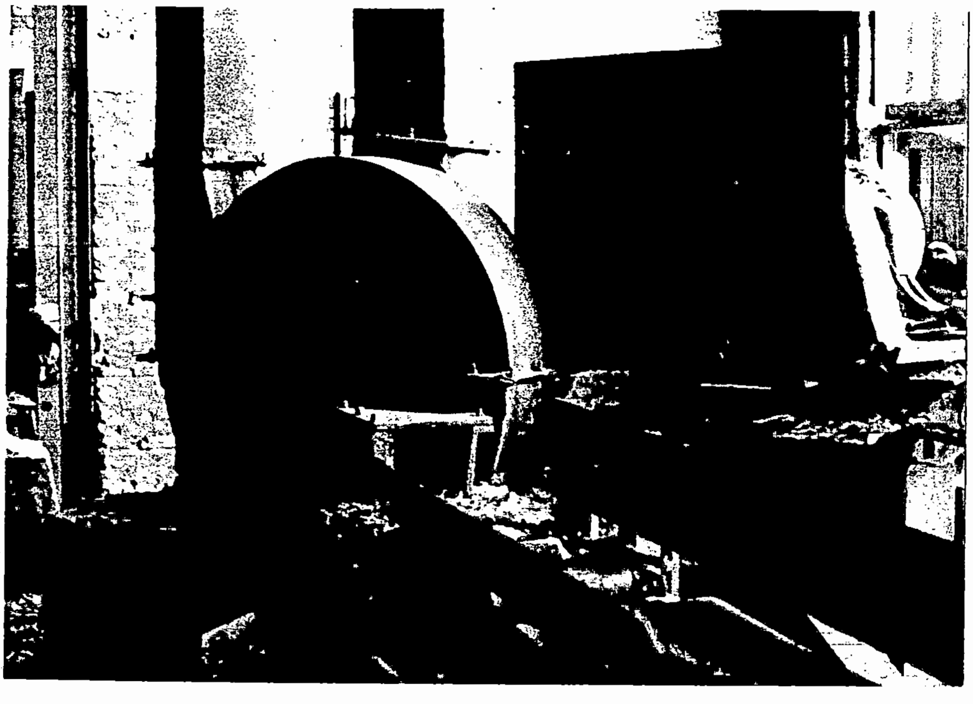
9. Chip Feed Auger



10. New Stationary Chipper

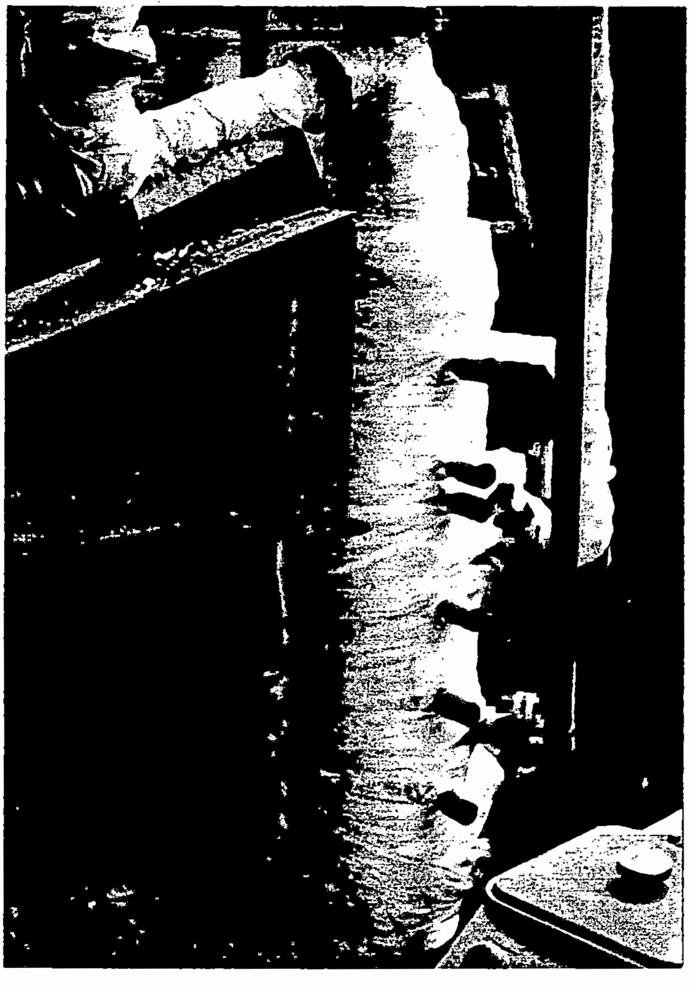


11. Pulp Mill Chip Screen



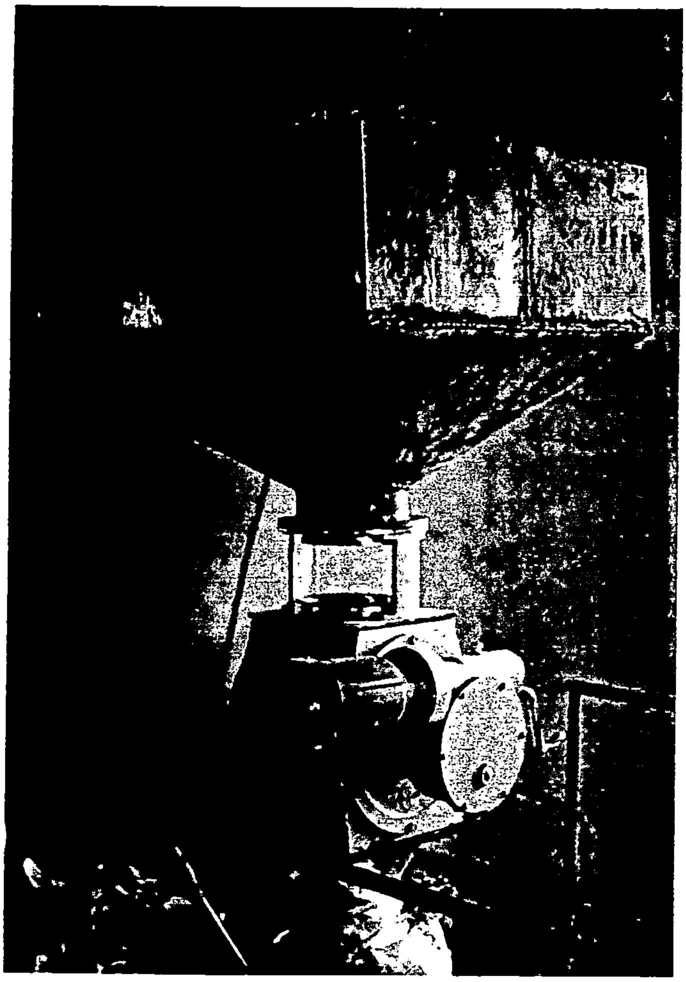
12. Pulp Mill Chipper

13. Two-stage Laboratory Gasifier



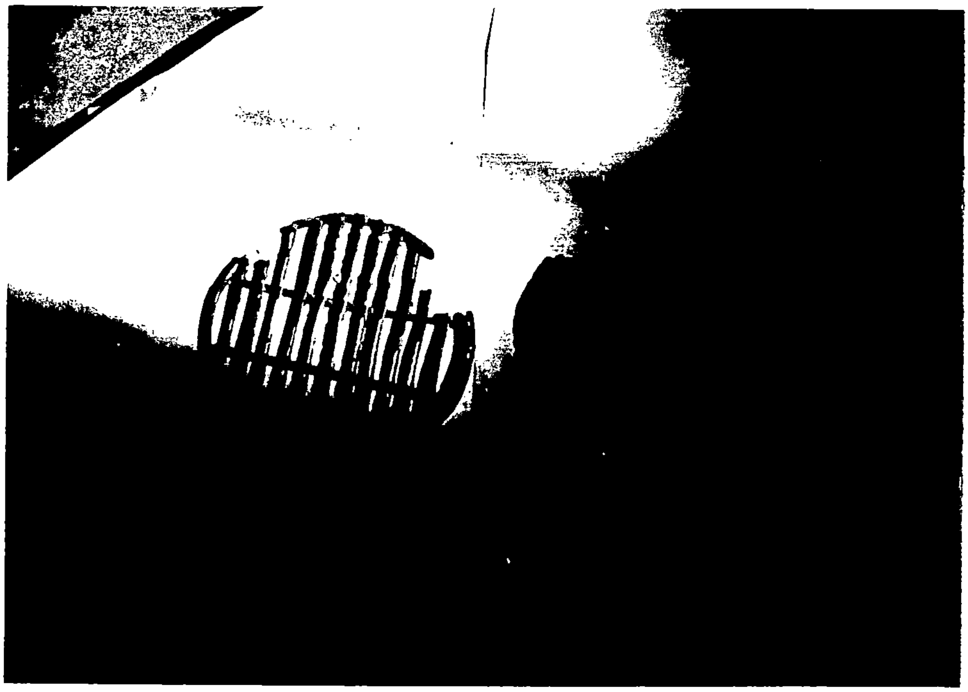
14. Char Transfer Auger and
Thermal Cracking Stage

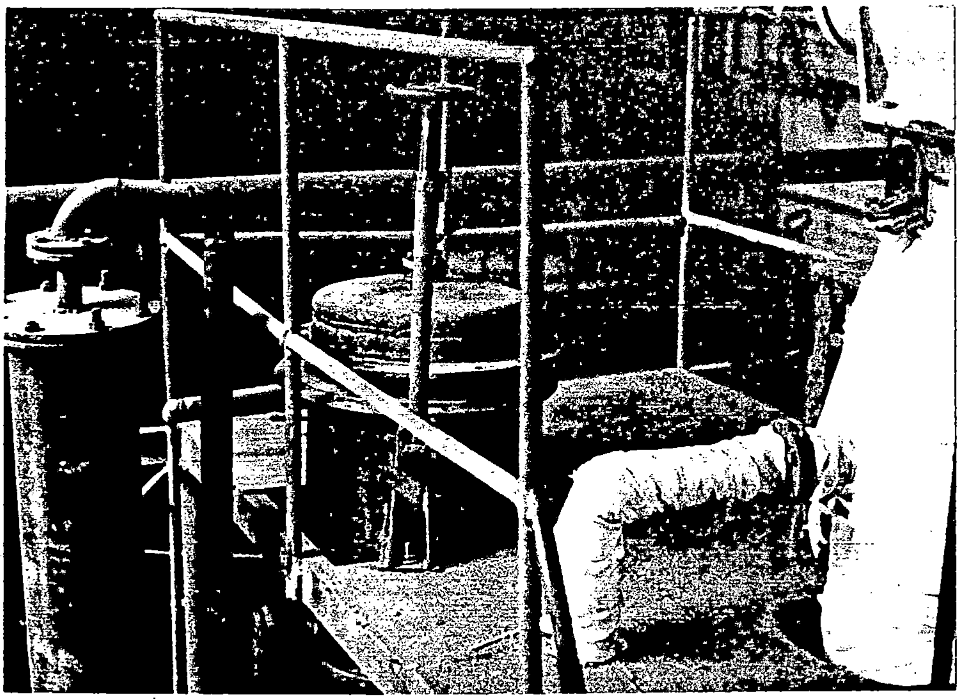
APPENDIX 1. SUB-PROJECT II



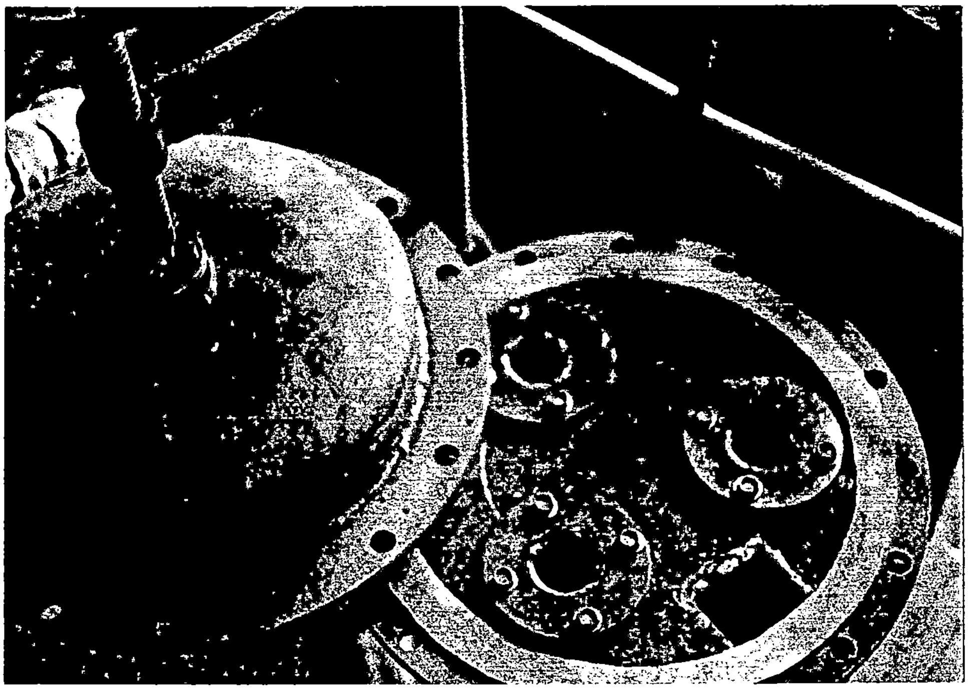
15. Feed Hopper and Rotary Valve

16. Second Stage Grate Sections

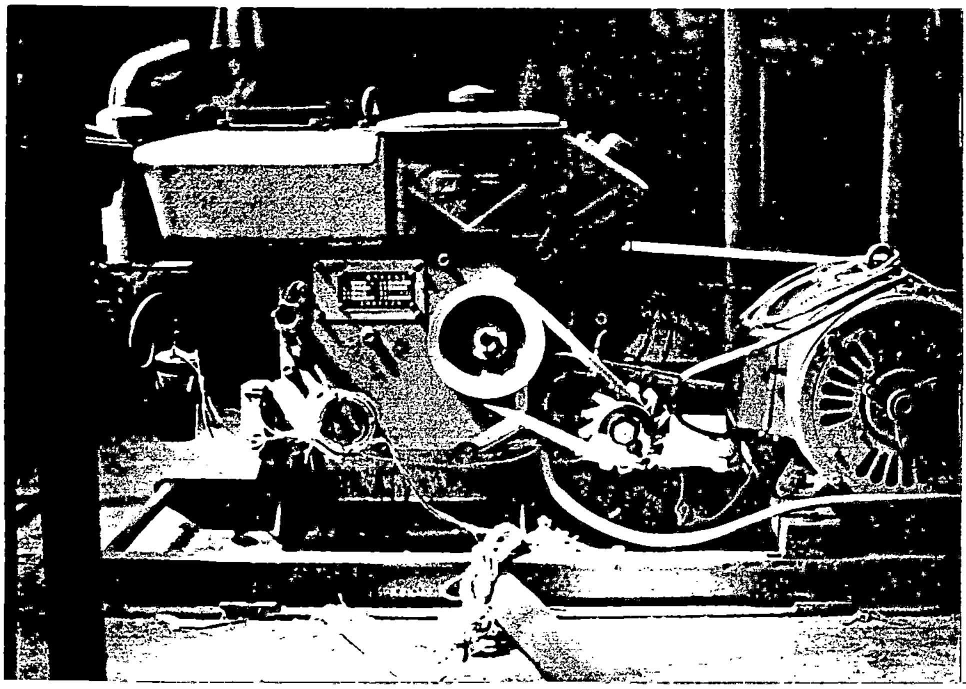




17. Wet Scrubber and Final Filter

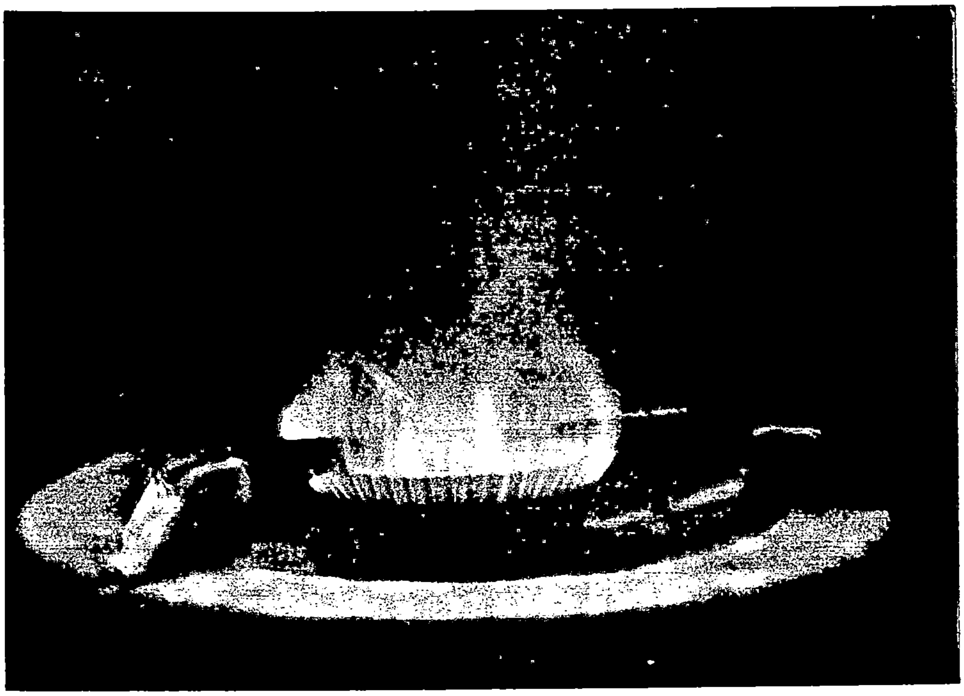


18. Filter Internal Configuration

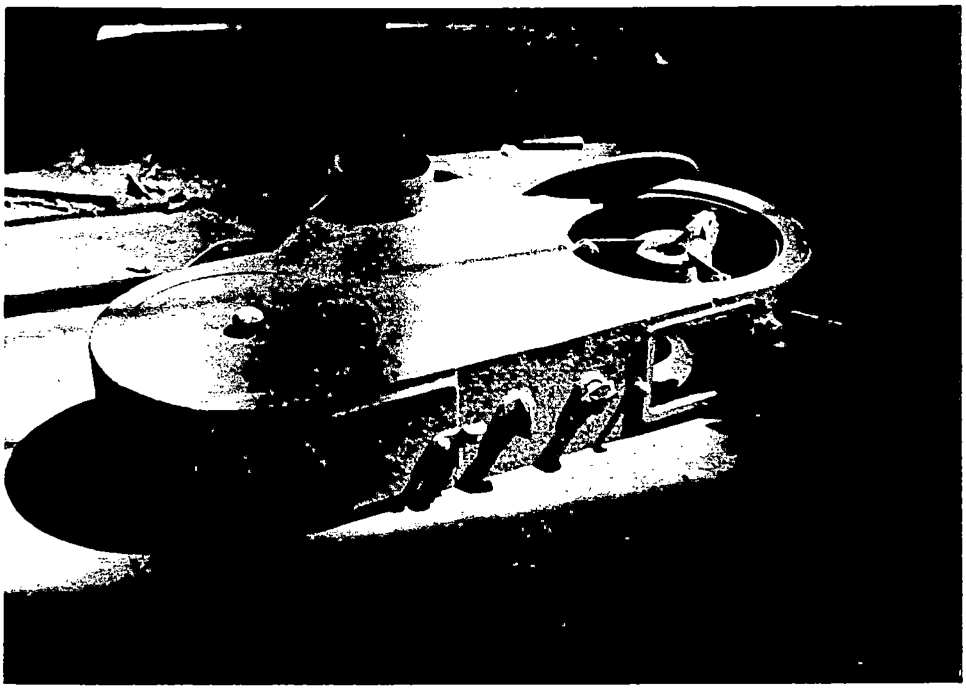


19. Five kilowatt Engine-Generator Set

APPENDIX 1. SUB-PROJECT IV (PROPOSED)



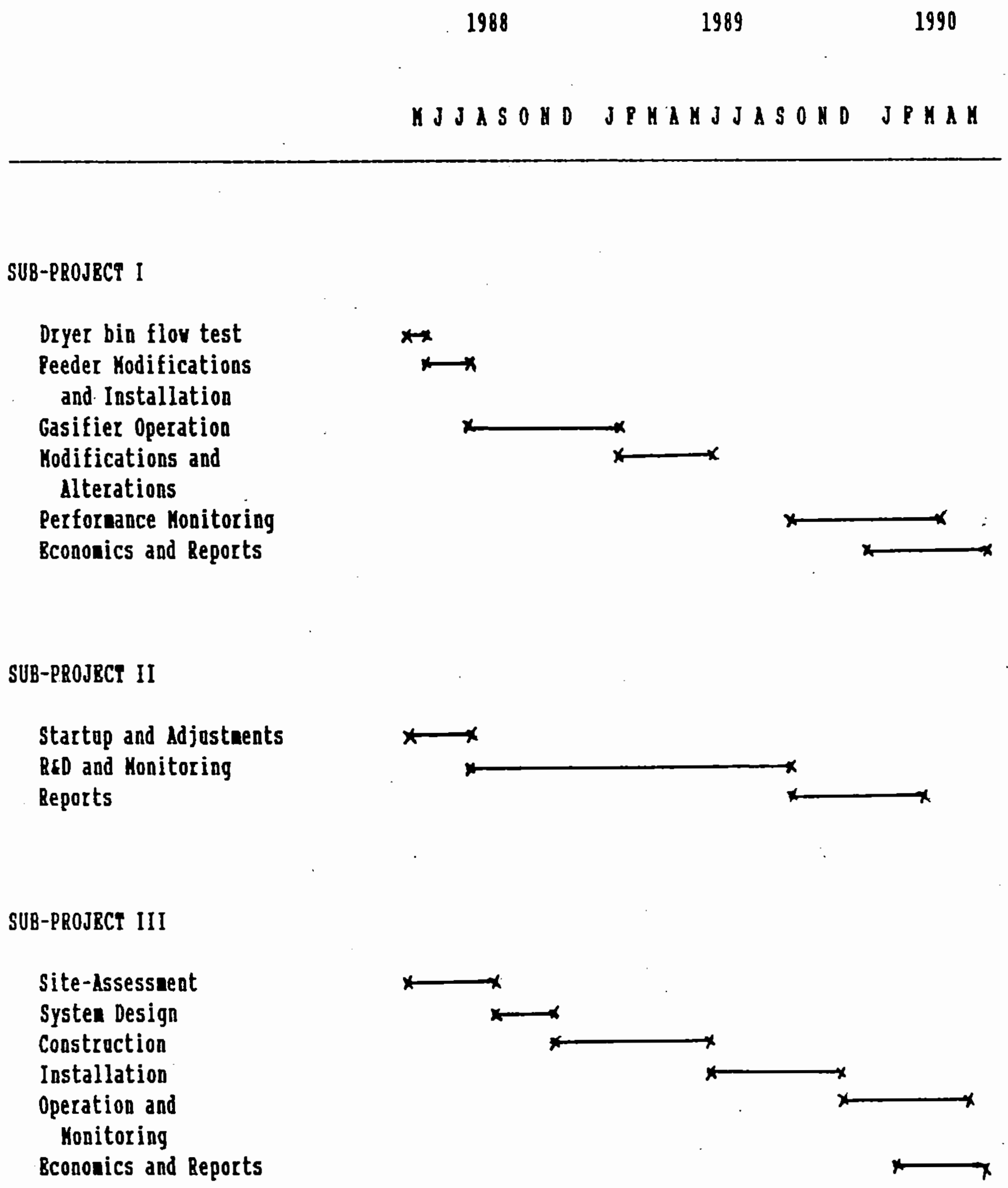
20. Commercial Stove Burning Coal-gas in Harbin Apartment



21. Commercial Coal-gas Stove to be Tested at Laboratory

APPENDIX II.

APPENDIX II. REVISED SCHEDULE



APPENDIX III.

APPENDIX III SUB-PROJECT IV PROPOSAL

Background

The government of China has been increasing the pressure to reduce fuelwood consumption since the present forest yearly growth increment is lower than present harvest. Last year large losses from extensive forest fires have focussed government attention on the forest communities since each year family cooking and fuelwood gathering activities contribute to forest fire initiation. Also, the large piles of dry stovewood in each families yard constitute a fire hazzard to the homes and consequently to the forests.

The government feels that industry can convert from solid wood to coal easier than the forest communities, therefore there is pressure to address the reduction of solid wood use for forest family cooking. Conversion of the central hot water district heating systems to steam would allow cooking of rice but would not provide sufficiently high temperatures for most cooking requirements. Co-generation of electricity would be technically feasible but would be very expensive since the capital cost would be very high for sufficient capacity to handle the peak demand when all families would be cooking meals at the same time. Also, generation of electricity when there would be no heating load is very inefficient. It is felt that a central gas generator and distribution system offers the greatest potential since overall conversion efficiency is relatively good and using a gas storage tank would allow a small gasifier to build up a gas reserve to meet the peak demand at mealtime.

Household cooking with low to medium energy gas containing 10-30% CO is not new to China since there are presently over 500,000 families using piped in coal-gas or refinery gas. (Table 1). While the presence of CO is a health hazzard and deaths do result from CO poisoning the death ratio is considered very low by Chinese standards. The average of roughly 6 deaths per year per 100,000 family units served includes deaths of workers involved in the production and transmission of the gas. Worker deaths appear to form the majority with relatively few actual household cases of CO poisioning.

Table 1. Coal-gas Utilization Fatalities

CITY	CO (%)	FAMILY UNITS SERVED	DEATHS PER 100,000 FAMILY UNITS
SHENYANG	12	80,000	2.8
SHANGHAI	20	410,000	1.3
HARBIN	25	14,000	7.0
DALIAN	17	12,000	12.7

APPENDIX III.

General Objectives

It is proposed to conduct an experimental and demonstration project with the following two broad objectives:

1. To conduct research to improve the quality of gas derived from an updraft wood-chip gasifier in order to confirm its suitability for use in an existing low-energy gas stove.

2. To establish a demonstration project in a selected forest community and provide low-energy wood gas via pipeline to a group of 50-100 homes for use in cooking.

Specific Objectives

The specific objectives would include those already incorporated in Sub-Project 2 regarding wood-gas quality improvement plus an expanded test at RICPUFP and a demonstration at a selected site in north-east China. These include:

1. Use of a thermal/catalytic cracker to increase hydrocarbon content by reduction of the tar/oil fraction.

2. Modifications to gasifier operating parameters to alter the wood-gas composition.

3. Investigation of methanation catalysts to reduce CO content in the gas.

4. Tests of an existing coal-gas stove on upgraded wood-gas and modification of the burners if required to achieve effective, safe, efficient combustion.

5. Extended duration practical cooking test at RICPUFP to assess gas storage, transmission, metering and combustion. Simulation of an actual application would familiarize project staff with low-energy gas cooking procedures as the basis for training during the on-site demonstration.

6. Selection of a test site, construction and installation of an improved gasifier, and installation of in-home cook-stoves with appropriate safety systems.

7. Operation of the system for demonstration, testing & monitoring.

8. Socioeconomic evaluation of the wood-gas cooking application and preparation of reports.

APPENDIX III.

Expected Benefits

The expected benefits from implementation of a wood-gas distribution system for household cooking are:

1. Reduction in total fuel use as a result of improved overall efficiency.

2. Release of solid wood (stovewood) for traditional forest products through utilization of chipped forest residuals as fuel.

3. Reduced risk of household fires and forest fires by eliminating large wood piles in proximity to the houses and of family cutting of firewood in the forest.

4. Improved family conditions from reduced time and effort required for meal preparation.

Methodology

Gas Quality Improvement

The laboratory tests to improve the cooking gas quality and confirm the suitability of the coal-gas stove for operation on low-energy wood gas would be carried out as originally projected.

Laboratory Cooking Simulation

A small gas storage tank, external pipe loop and industrial gas metering unit would be installed at the laboratory to test gas transmission aspects.

A small enclosed room already located in the corner of the laboratory would be fitted with the existing gas cook-stove as a simulated "kitchen". The room would be fitted with a CO monitor to determine CO levels under normal operating conditions, establish effects of gas leakage, and determine if the external stove vent and safety switches are adequate. The stove would be used by project staff for cooking, water heating, etc. which will provide experience to the staff for stove operation training programs required for the field demo.

Field Demonstration

It is proposed that a demonstration project be conducted involving a forest community of 50-100 families. Possible sites are the forest community of Daxinganling, north-east of Dialing (whose officials have expressed strong interest in the demonstration of household cooking with gas), or at the Bi Shui forest farm of Sub-project 1. Selection would be based on gas distribution costs (the degree of concentration of the homes), the availability and price of fuel chips and the degree of cooperation anticipated from the residents and officials on the site.

APPENDIX III.

The system capacity has been estimated as 150-200,000 K Cal/h This is based on the average energy requirement for cooking of 1300 K Cal/person/day, an average family size of 5 (in the northeast forest area) and a gas stove burning efficiency of 50-60%. With a gas heating valve of about 1000 K Cal/m3 the gas requirement would be 12m3/family/day. The gasifier with a capacity of 150-200 m3/h would then operate from 6-9 hours/day to produce the gas required for a community of 100 families. With a gasifier efficiency of 60-70%, about 50-55 kg wood are required per 100m3 of gas. Fuel requirement would therefore be 450-990 kg/day.

The system, based on the improved two-stage gasifier under development in the laboratory (Sub-Project 2), would be installed, tested and modified as required. When fully operational a test monitoring period of several months operation would be carried out. Socioeconomic studies would be conducted to assess the economic and social impact of the system and reports prepared.

APPENDIX III.

Proposed Budget

Item	Description	Cost (CY)
1	Chipper	25,000
2	Chip Screen	3,000
3	Gasifier Feed System	5,000
4	Gasifier	10,000
5	Tar Cracker	6,000
6	Char Transfer Screw	1,000
7	Cyclone	500
8	Scrubbers	5,000
9	Filter	2,000
10	Storage Tank	60,000
11	Air Blower	700
12	Gas Compressor	2,850
13	Gas Piping	60,000
14	100 Stoves	20,000
	TOTAL	201,050
	(Displaced from Sub-Project 3)	
	Gasifier & Burner	110,900
	Gas Cleaning & Engine-Generator	72,800
	TOTAL	183,700
	NET DIFFERENCE	+17,350

APPENDIX III.

Proposed Schedule: (Sub-Project IV)